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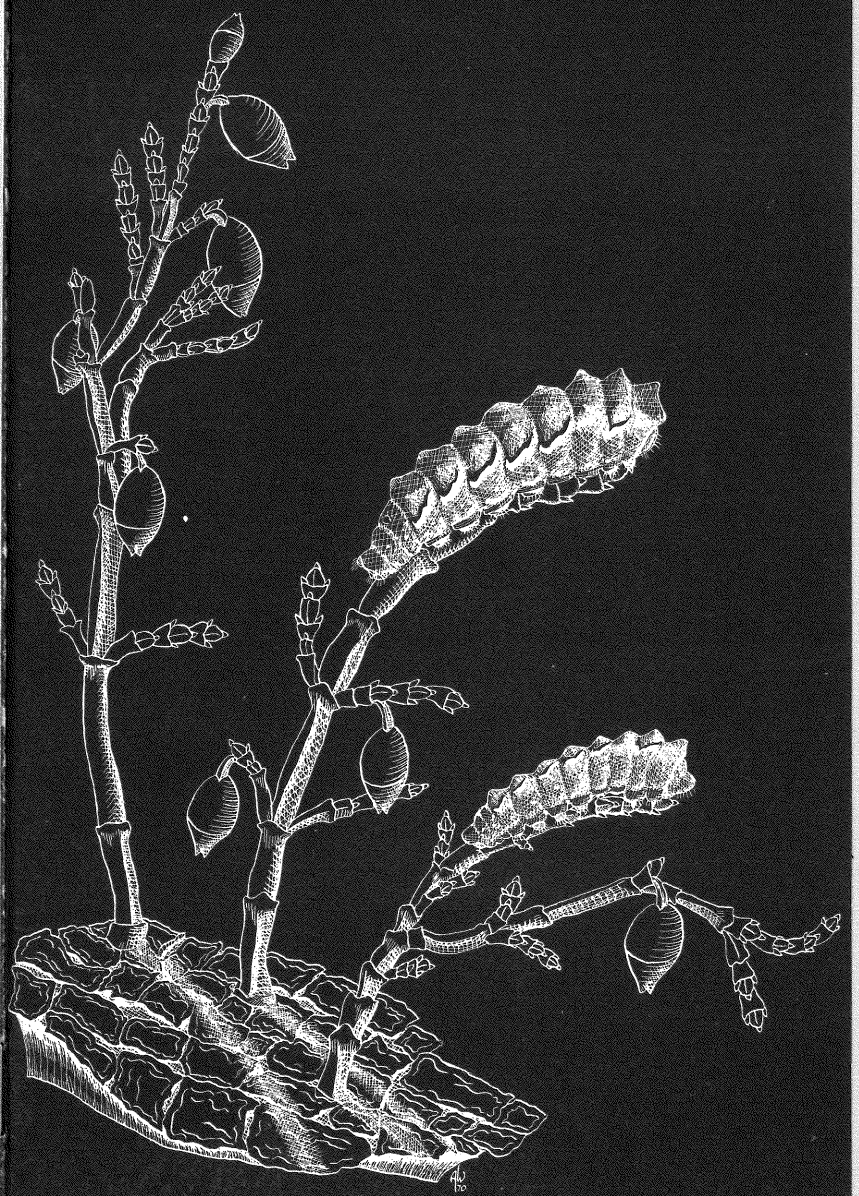

INSECTS and MITES ASSOCIATED WITH DWARF MISTLETOES

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Abstract

Three main ecological relationships are recognized between arthropods and dwarf mistletoes (Arceuthobium spp.); the arthropods pollinate and feed on the dwarf mistletoes, and mistletoe infection may predispose trees or parts of trees to attack by insects, especially bark beetles (Scolytidae). Diptera, Hymenoptera, and Thysanoptera are the main pollinators. Larvae of Lepidoptera are the most important group of insects that feed on dwarf mistletoes, at times causing severe damage to external portions of plants. Several species of mites (Acarina) are common associates; their relationship with the host is unknown. Biological control may be possible through manipulating populations of insects that feed on or pollinate mistletoe.

Key words: Arceuthobium, biological control, pollination

ABOUT THE COVER:

Larvae of the thicket hairstreak butterfly, Mitoura spinetorum Hewitson, in typical feeding position on dwarf mistletoe shoots. Drawing by Anne Steely.

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Insects and Mites Associated with Dwarf Mistletoes

Robert E. Stevens and Frank G. Hawksworth

Dwarf mistletoes, Arceuthobium spp., parasitize conifers in North and Central America, Africa, and Eurasia, but most species are confined to the New World. In many parts of the western United States they are serious economic pests (Gill and Hawksworth 1961).

The literature on insects associated with other mistletoes is extensive (Schumacher 1918, Gill and Hawksworth 1961). Some of the more detailed accounts have been on Viscum album in Europe (Tubeuf 1923), Phoradendron flavescens in the United States (Tucker 1922), and Loranthus longiflorus in West Pakistan (Baloch and Mohyuddin 1969). The insects associated with the dwarf mistletoes have not been comparably reviewed, however. Hawksworth (1961) listed several species of insects found on Arceuthobium vaginatum subsp. cryptopodum,[2] a parasite of Pinus ponderosa Laws. in the southwestern United States, and several other insects have been reported on Arceuthobium. It is our purpose in this Paper to summarize all of this literature, and to present previously unpublished information on arthropods (insects and mites) associated with the dwarf mistletoes of the western United State and Mexico.[3]

[2]*The scientific names for Arceuthobium used in this paper are from "Biology and classification of the dwarf mistletoes," by Frank G. Hawksworth and Delbert Wiens, U. S. Dep. Agr., Agr. Handb. (in press). In the Arceuthobium campylopodum group, the specific names are usually the same as the form names used by Gill (1935). Exceptions are A. "occidentale"--a California species on Pinus sabiniana, P. radiata, and P. muricata; A. "californicum"--a species principally on Pinus lambertiana in California and southern Oregon; and A. "apachecum"--on Pinus strobiformis in southwestern United States and northern Mexico.*

[3]*The authors express their thanks to the many taxonomists who identified the insects.*

Arthropod-Dwarf Mistletoe Relationships

Several kinds of insects and mites are associated with dwarf mistletoes, and these associations involve three main ecological relationships. Of these, two are direct relationships that involve insects as consumers and pollinators of dwarf mistletoe plants. A third, indirect, relationship concerns dwarf mistletoe infection predisposing trees or parts of trees to attack by insects. The relationship between dwarf mistletoes and insects has been somewhat of a "no-man's land" between forest entomology and forest pathology that has scarcely been investigated.

Most of the direct arthropod-dwarf mistletoe associations we report involve insects feeding on or pollinating dwarf mistletoe plants. However, in some instances—especially with mites—the relationship is unclear, and we do not know for certain what the arthropod is doing in or on the host plant.

Several of the arthropod species recorded in the literature are represented by a single or only a few collections. Again this is especially true for the mites, and probably reflects lack of attention rather than rarity of occurrence.

Pollination of Dwarf Mistletoes

Arthropods—especially insects—appear to play the major role in dwarf mistletoe pollination (Hawksworth 1961, Kuijt 1955, Weir 1915). Evidence for this centers on characters of insect pollinated plants demonstrated by Arceuthobium: spined pollen shed in clusters, relatively limited amount of pollen, nectar production, and odor emission by both male and female flowers, along with the presence of numerous insects in and on the flowers during the flowering period. Some wind pollination may occur, but probably only within a meter or so.

The most consistent association we have observed (table 1) is pollination of A. vaginatum subsp. cryptopodum by thrips. Thrips, including a species of Frankliniella and possibly others, occur essentially throughout the range of this mistletoe in the Southwest and in Colorado (Hawksworth 1961).

Table 1.--Insects known or suspected to pollinate dwarf mistletoes

Insect	Host	Tree	Locality	Reference[1]	Remarks
THYSANOPTERA--Thrips					Thrips are small insects, generally less than 2 mm. long, with fringed wings. *Thrips tabaci*, the undescribed *Frankliniella* (O'Neill, Kellie. 1970. Proc. Wash. Entomol. Soc. 72, in press), and *F. occidentalis* are common on *A. vaginatum* subsp. *cryptopodum* in southwestern United States; together these are thought to be its primary pollinators (Hawksworth 1961). *F. occidentalis* is widespread throughout North America; it is found commonly in the flowers of a broad range of plants (Essig 1958). *T. tabaci*, an even more widespread thrips, occurs throughout Europe and North America; Essig (1958) indicates that it feeds on a wide variety of crops.
Thrips tabaci Lindeman	*A. vaginatum* subsp. *cryptopodum*	*Pinus ponderosa*	Ariz.; N. Mex.	Hawksworth 1961	
Frankliniella occidentalis (Pergande)	do	do	do	do	
Frankliniella sp.	do	do	do	do	
Sericothrips sp. (probably)	*A. divaricatum*	*P. edulis*	Jacob Lake, Ariz.	(K. O'Neill)	
Do	*A. cyanocarpum*	*P. flexilis*	Bryce Canyon, Utah	do	
Unidentified thrips	*A. oxycedri*	*Juniperus*	Europe	Heinricher 1915	
Do	*A. campylopodum*	*Pinus ponderosa*	Riggins, Idaho	(Hawksworth)	
Do	do	do	Pringle Falls, Oreg.	do	
Do	do	do	Charleston Mts., Nev.	do	
Do	*A. douglasii*	*Pseudotsuga menziesii*	Bryce Canyon, Utah	do	
Do	do	do	San Francisco Peaks, Ariz.	do	
HYMENOPTERA					
Unidentified hymenopterous insects	*Arceuthobium* spp.	not given	Northwestern U. S.	Weir 1915	
Formicidae--Ants					
Formica integra tahoensis Wheeler	*A. cyanocarpum*	*Pinus flexilis*	Cody, Wyo.	(R. E. Gregg)	
F. sanguinea subnuda Emery	*A. americanum*	*P. contorta*	Larimer County, Colo.	do	
Lasius niger neoniger Emery	do	do	do	do	
Tapinoma sessile (Say)	do	do	do	do	
Unidentified ants	do	do	British Columbia	Kuijt 1955	
Do	*A. vaginatum* subsp. *cryptopodum*	*P. ponderosa*	Ariz.; N. Mex.	Hawksworth 1961	
Apidae--Honey bees					
Apis mellifera Linnaeus	*A. campylopodum*	*Pinus*	Calif.	Coleman 1921	
DIPTERA					
Sciaridae--Root gnats					These small, fragile flies are common in and around dwarf mistletoe plants during the flowering period. An observation (June 1, 1962) on *A. americanum* in Larimer County, Colorado, showed 51 percent of the ♂ plants (n=88) being visited by *Bradysia*, compared with 26 percent of the ♀ plants (n=31).
Bradysia sp.	*A. americanum*	*P. contorta*	Larimer County, Colo.	(A. Stone)	
Unidentified flies	do	do	Uinta Mts., Utah	(D. Wiens)	

[1]References in parentheses are original; insects were identified by individual named.

During the flowering period, these normally dark insects appear yellow due to the masses of pollen transported on their bodies. Coleman (1921) records Arceuthobium campylopodum as a honey plant in California, so honeybees may also be involved in pollination of the species. W. V. Showalter (personal communication 1968) has observed bumblebees, other bees, and thrips apparently involved in pollination of A. campylopodum on ponderosa pine in California.

Our observations of Arceuthobium americanum in Colorado suggest that ants and flies are its primary pollinators. Early in the flowering period, small flies, particularly Bradysia sp. (Sciaridae), are most common, but toward the end of the flowering period the flies are succeeded by ants. Formica sanguinea subnuda Emery, Lasius niger neoniger Emery, and Tapinoma sessile (Say) have all been observed to frequent flowering plants and to transport pollen.

Some phytophagous insects (table 2) may be passively involved in pollination if their season of activity coincides with the flowering period of their host.

Cooperative University of Utah-Rocky Mountain Station studies on the pollinators of Arceuthobium americanum are currently being conducted by Dr. Delbert Wiens.

Insect Feeding on Dwarf Mistletoes

Several kinds of insects—especially larvae of Lepidoptera—feed on dwarf mistletoe plants (table 2). In some cases they are highly destructive. With a few exceptions the insects that feed on dwarf mistletoe have not been commonly collected, and little is known of their life histories and other characteristics. Three species of Lepidoptera, Filatima natalis (Heinrich), Dasypyga alternosquamella Heinrich, and Mitoura spinetorum (Hewitson), appear to be specific to Arceuthobium, and are broadly distributed throughout its range in western North America. Neoborella tumida Knight, a mirid bug, is also widely distributed in the West and appears to be restricted to Arceuthobium. The Lepidoptera larvae can all be highly destructive to individual plants, but the impact of their feeding on a broad scale has not been evaluated. N. tumida, while widely recognized as a dwarf mistletoe associate, has only this past season been conclusively found feeding on the host; the effect of its feeding has not been studied.

Table 2.--Insects known or reported to feed on dwarf mistletoe

Insect	Host	Tree	Locality	Reference[1]	Remarks
ORTHOPTERA					
Unidentified grasshoppers	*A. campylopodum*	*Pinus ponderosa*	Spokane, Wash.	Weir 1915	
HEMIPTERA (HETEROPTERA)					
Miridae--Plant bugs					Plant bugs are sucking insects that generally feed on plant saps and juices. *N. tumida* is a widespread associate of dwarf mistletoes throughout the western United States. It is recorded from *A. campylopodum* in eastern Oregon (Ochoco Divide, Wheeler County and Pringle Butte, Deschutes County), *A. vaginatum* subsp. *cryptopodum* in Arizona and New Mexico, *A. cyanocarpum* in Arizona (San Francisco Peaks) and Colorado (Boulder County), and from *A. "occidentale"* at Monterey, California. Details of its life history and habits will be reported later, but *N. tumida* has a typical mirid life history; it overwinters in the egg stage, and probably has a single annual generation. The impact of feeding is not obvious.
Neoborella tumida Knight	*A. vaginatum* subsp. *cryptopodum*	do	Colo., Ariz., N. Mex.	Hawksworth 1961	
Do	do	do	Davis Mts., Tex.	(Hawksworth)	
Do	*A. "occidentale"*	*P. radiata*	Monterey, Calif.	do	
Do	*A. divaricatum*	*P. edulis*	Ariz., N. Mex., Utah	do	
Do	do	*P. cembroides*	Davis Mts., Tex.	do	
Do	*A. cyanocarpum*	*P. flexilis*	Colo., Utah	do	
Do	*A. campylopodum*	*P. ponderosa*	Oreg.	do	
Do	*A. "apacheum"*	*P. strobiformis*	Mt. Lemmon, Ariz.	Knight 1925	
Do	*A. americanum*	*P. contorta*	Colo.	(Knight)	

See footnote at end of table, p. 6.

Table 2.--Insects known or reported to feed on dwarf mistletoe--continued

Insect	Host	Tree	Locality	Reference[1]	Remarks
Neoborella sp.	*A. vaginatum* subsp. *vaginatum*	*Pinus hartwegii*	Puebla, Mexico	(Knight)	A specimen from *A. vaginatum* subsp. *vaginatum* from Popocatepetl--Ixtacciuatl National Park, State of Puebla, Mexico, was identified by Knight as *Neoborella* sp., possibly *N. tumida*. Knight also reports (personal communication, November 25, 1969) that another undescribed species may be associated with *Arceuthobium* in Arizona.
HEMIPTERA (HOMOPTERA)					
Diaspididae--Armored scales					
Diaspis visci Schrank	*A. oxycedri*	*Juniperus oxycedrus*	Europe	Schumacher 1918	
Chionapsis striata Newst.	do	*Juniperus* spp.	Europe	Lindinger 1912	
Hemiberlesia rapax (Comstock)	*A. "occidentale"*	*Pinus radiata*	Monterey County, Calif.	(H. L. McKenzie)	
Hemiberlesia sp. (Undescribed)	*A. vaginatum* subsp. *durangense*	*P. montezumae*	Sinaloa, Mexico	(R. F. Wilkey)	
Niveaspis vulcania Ferris	*A. gillii* subsp. *nigrum*	*P. lumholtzii*	Durango, Mexico	do	Scale insects are rare on *Arceuthobium* in the U.S., but seem to be more common on material collected from Mexico. Many plants collected in 1963 had shoots that were almost 50 percent covered by *N. vulcania*; however, there was no apparent damage.
Do	do	*P. teocote*	do	do	
Do	do	*P. leiophylla*	do	do	
Do	*A. strictum*	*P. teocote*	do	do	
Do	do	*P. chihuahuana*	do	do	
Do	*A. verticilliflorum*	*P. engelmannii*	do	do	
Do	*A. vaginatum* subsp. *vaginatum*	do	do	do	
Do	*A. vaginatum* subsp. *durangense*	*P. montezumae*	do	do	
Do	*A. globosum*	*P. cooperi*	do	do	
Do	do	*P. michoacana*	Oaxaca, Mexico	do	
Niveaspis sp. (undescribed)	*A. gillii* subsp. *nigrum*	*P. teocote*	Veracruz, Mexico	do	
Pseudoparlatoria serrulata T. & C.	*A. bicarinatum*	*P. occidentalis*	Dominican Republic	do	
Unidentified black scale	*A. vaginatum* subsp. *cryptopodum*	*P. ponderosa*	Ariz., N. Mex.	Hawksworth 1961	

See footnote at end of table, p. 6.

Table 2.--Insects known or reported to feed on dwarf mistletoe--continued

Insect	Host	Tree	Locality	Reference[1]	Remarks
Cercopidae--Spittlebugs					Spittlebugs are also sucking insects, some of which are important plant pests. The common name refers to the habits of the nymphs (immature forms), that live and feed in masses of frothy "spittle." Korstian and Long (1922) considered *C. obtusa* to be the most conspicuous insect species found on *A. vaginatum* subsp. *cryptopodum*; it is widely distributed throughout the southwestern United States. Heavy populations can destroy entire dwarf mistletoe shoots, but it is rarely abundant enough to cause much damage (Hawksworth 1961). While *C. obtusa* has commonly been cited as a species infesting dwarf mistletoes, it appears that only a single presumably authoritative identification has been made. The fact that *C. obtusa*--known as the "alder spittlebug"--is well known from somewhat different kinds of hosts casts a question on the proper identity of the species actually involved with dwarf mistletoes. On the other hand, Essig (1958) lists *C. obtusa* from "red cedar" in addition to its more common broadleaf hosts. This implies a diverse host range and makes *Arceuthobium* a more likely food plant.
Clastoptera obtusa (Say)	*A. vaginatum* subsp. *cryptopodum*	*Pinus ponderosa*	Ariz., N. Mex.	Korstian and Long 1922	
Do	do	do	Pike National Forest, Colo.	Gill 1935	
Do	*A. abietinum*	*Abies concolor*	Grand Canyon, Ariz.	(Hawksworth)	
Unidentified spittlebug	*A. "occidentale"*	*Pinus radiata*	Monterey, Calif.	Gill 1935	
LEPIDOPTERA					
Gelechiidae--Gelechiid moths					
Filatima natalis (Heinrich)	*A. vaginatum* subsp. *cryptopodum*	*P. ponderosa*	Manitou, Colo.	Heinrich 1921	Larvae of *F. natalis*, *Dasypyga alternosquamella*, and an unidentified pyralid commonly destroy shoots of *A. vaginatum* subsp. *cryptopodum* in southwestern United States. According to Hawksworth (1961), the larvae not only mine out larger shoots, but also feed on the younger shoots and seeds. Heinrich (1921) recording from Ashland, Oreg., indicates that *F. natalis* and *D. alternosquamella* are common associates, and larvae of each species are equally numerous in his collections. *F. natalis* is found in the literature under its old generic name of *Gelechia*.
Do	*A. douglasii*	*Pseudotsuga menziesii*	Ashland, Oreg.	do	
Coleotechnites sp.	*A. pusillum*	*Picea mariana*	E. Canada	(T. N. Freeman)	*Coleotechnites* sp. is reported to mine out shoots of dwarf mistletoe (J. Hamai, personal communication, February 1969).
Geometridae--Loopers					
Unidentified geometrids	*A. vaginatum* subsp. *cryptopodum*	*Pinus ponderosa*	Ariz., N. Mex.	Hawksworth 1961	
Do	*A. "occidentale"*	*P. muricata*	Ft. Bragg, Calif.	(Hawksworth)	

See footnote at end of table, p. 6.

Table 2.--Insects known or reported to feed on dwarf mistletoe--continued

Insect	Host	Tree	Locality	Reference[1]	Remarks
Lycaenidae--Hairstreaks					The hairstreaks, favorites of amateur lepidopterists, are a large group of small to moderate sized butterflies. *M. spinetorum*, an especially attractive species, is widely distributed throughout montane western North America, from southern British Columbia to central Mexico. Shields (1965) gives a thorough review of its distribution and hosts, along with those of *M. johnsoni*. The larvae of *M. spinetorum* feed on all external parts of the dwarf mistletoe plant. The form of the larva, slug-like and with the segments irregularly folded and ridged, strongly resembles that of the host. This, coupled with the tendency of the larvae to take on the color of ingested food and a total lack of webbing, results in an excellent example of mimicry. The adult has been widely collected, and this has contributed much to the abundant distribution records compiled by Shields (1965). *Mitoura spinetorum* feeds on several species of *Arceuthobium*, while *M. johnsoni* has been recorded only on hemlock dwarf mistletoe, *A. tsugensis*. However, another host is likely for *M. johnsoni*, as Shields (1965) records it from several locations in which *A. tsugensis* does not occur. Shields (1965) presents excellent colored photos of adults of both *Mitoura* species. *M. spinetorum* can cause severe damage to dwarf mistletoe plants. We have observed infections of *A. americanum* in Larimer County, Colorado, in which external portions of plants have been heavily damaged by larval feeding continuing over several seasons.
Mitoura spinetorum (Hewitson)	*A. vaginatum* subsp. *cryptopodum*	*Pinus ponderosa*	Ariz., Colo.	Hawksworth 1961	
Do	*A. campylopodum*	do	Calif.	Comstock and Dammers	
Do	*A. "occidentale"*	*P. sabiniana*	Mt. Diablo, Calif.	Tilden 1960	
Do	*A. divaricatum*	*P. edulis*	Ariz.	Garth 1950	
Do	do	*P. monophylla*	Calif., Nev.	Shields 1965	
Do	*A. americanum*	*P. contorta*	Larimer County, Colo.	Remington 1958	
Do	*A. abietinum*	*Abies concolor*	Calif.	Shields 1965	
Do	*A. blumeri*	*Pinus strobiformis*	Ariz.	do	
Do	*A. cyanocarpum*	*P. aristata*	Ariz.	do	
Do	*A. laricis*	*Abies lasiocarpa*	Wash.	do	
Do	do	*Larix occidentalis*	Wash.	do	
Do	*A. globosum*	*Pinus michoacana*	Mexico	do	
M. johnsoni (Skinner)	*A. tsugensis*	*Tsuga heterophylla*	Southern British Columbia, Canada; E. Oreg., E. Wash.	do	
Do	do	*T. mertensiana*	Sierra Nevada Mts., Calif.	do	
Lymantriidae--Tussock moths					
Orgyia antiqua (L.)	*A. americanum*	*Pinus contorta*	Targhee National Forest, Idaho	(E. L. Todd)	This tussock moth was reported from the Targhee National Forest in southeastern Idaho in 1954 and 1958. Often found in the literature under the genera *Notolophus* and *Hemerocampa*, *O. antiqua* is known to be a feeder on a broad range of woody plants, but little is known of its habits on dwarf mistletoes. However, J. L. Mielke (personal communication, 1959) reported nearly 100 percent of host shoots being destroyed in the southeastern Idaho outbreak, and indicated that it did not feed on the pine foliage.
Pyralidae--Pyralid moths					
Dasypyga alternosquamella Raganot	*A. vaginatum* subsp. *cryptopodum*	*P. ponderosa*	Colorado	Heinrich 1921	This moth is another important destroyer of *A. vaginatum* subsp. *cryptopodum* and *A. campylopodum*, and is recorded from Colorado, Oregon, and California. Heinrich (1921) comments that "Larvae feed singly and externally and while normally very abundant are easily overlooked on account of their protective coloration. The color of the individual larvae varies in harmony with the color of the individual batches of mistletoe on which they feed." Heinrich also indicates a single annual generation, with the insects overwintering as pupae in the ground. It is probable that *D. alternosquamella* is widely distributed throughout the range of ponderosa pine in the United States.
Do	*A. campylopodum*	do	Ashland, Oreg. Hobergs, Lake Co., Calif.	(W. D. Duckworth)	
Tortricidae--Leaf roller moths					
Tortricid nr. *Peronea*	*A. vaginatum* subsp. *cryptopodum*	do	Ariz., N. Mex.	Hawksworth 1961	
COLEOPTERA					
Curculionidae--Weevils					
Unidentified gray weevil	*A. vaginatum* subsp. *cryptopodum*	do	Ariz., N. Mex.	Hawksworth 1961	
Do	do	do	Larimer County, Colo.	(Hawksworth)	

[1]References in parentheses are original; insects were identified by individual named.

Mites

Several species of mites (table 3) have been collected from dwarf mistletoes. Brevipalpus porca Pritchard and Baker, a red tenuipalpid, is common throughout the southwestern United States. Typhlodromus arceuthobius Kennett is often associated with B. porca, and is probably a predator of it (Kennett 1963). Paraphytoptus arceuthobii Keifer is reported from staminate flowers (Keifer 1952). While B. porca and P. arceuthobii are members of phytophagous groups and could be expected to feed on the dwarf mistletoe plants, we have not seen this. B. porca, while not difficult to find, occurs in such low densities that visible damage would not be expected. The life history, habits, and ecological relationships of dwarf mistletoe-inhabiting mites remain to be learned.

Table 3.--Mites known to occur on dwarf mistletoes

Mite	Host	Tree	Locality	Reference[1]
MESOSTIGMATA				
Phytoseiidae				
Typhlodromus arceuthobius Kennett	*A. "occidentale"*	*Pinus sabiniana*	Mt. Diablo, Calif.	Kennett 1963
Do	do	do	Lake County, Calif.	Do
Do	do	do	Fiddletown, Amador County, Calif.	Do
Do	*A. campylopodum*	*P. jeffreyi*	Snow Lake, Plumas County, Calif.	Do
Do	do	do	Pinecrest, Tuolomne County, Calif.	Do
T. bakeri (Garman)	*A. pusillum*	*Picea mariana*	Stokes Bay, Ontario, Canada	Do
Do	do	do	Pine Tree Harbor, Ontario, Canada	Do
Do	do	do	Howdenvale, Bruce County, Ontario Canada	Do
Do	do	do	Outlet Park, Prince Edward County, Ontario, Canada	Do
T. validus Chant	*A. "occidentale"*	*Pinus sabiniana*	Lake County, Calif.	Do
Do	do	do	Fiddletown, Amador County, Calif.	Do
T. pusillus Kennett	*A. pusillum*	*Picea mariana*	Stokes Bay, Ontario, Canada	Do
Do	do	do	Howdenvale, Bruce County, Ontario, Canada	Do
Do	do	do	Troy, Cape Breton Island, Nova Scotia, Canada	Do
Typhlodromus sp. nr. *rosellus*	do	do	Red Bay, Ontario, Canada	Do
TROMBIDIFORMES				
Eriophiidae				
Paraphytoptus arceuthobii Keifer	*A. campylopodum*	*Pinus jeffreyi*	Lake Tahoe, Calif.	Keifer 1952
Do	*A. "occidentale"*	*P. sabiniana*	Mt. Diablo, Calif.	Do
Tenuipalpidae				
Brevipalpus porca Pritchard & Baker	*A. vaginatum* subsp. *cryptopodum*	*P. ponderosa*	Flagstaff, Ariz.	Pritchard & Baker 1958
Do	do	do	Fort Valley, Ariz.	Do
Do	do	do	Mescalero Indian Reserv., N. Mex.	Do
Do	do	do	Bryce Canyon, Utah	Do
Do	*Arceuthobium* sp.	do	Calif.	Kennett 1963
Do	*A. douglasii*	*Pseudotsuga menziesii*	Bryce Canyon, Utah	Pritchard & Baker 1958
Do	*A. divaricatum*	*Pinus edulis*	Jacob Lake, Ariz.	Do
Unidentified mites	*A. campylopodum*	*P. ponderosa*	Charleston Mts., Nev.	(Hawksworth)

[1]References in parentheses are original; insects were identified by individual named.

Increased Tree Susceptibility to Insects Induced by Dwarf Mistletoe

The question is often asked "Since both dwarf mistletoes and bark beetles (Scolytidae) kill trees, is there a relationship between the activity of the two pests?" Although an indirect relationship does exist (the few pertinent reports are summarized in table 4), none of the published reports seems to indicate that these are important in pines. Dwarf

Table 4.--Reports of dwarf mistletoes predisposing trees to attack by bark beetles[1]

Tree and dwarf mistletoe	Insect	Locality	Reference[2]
Pseudotsuga menziesii			
Arceuthobium douglasii	*Dendroctonus pseudotsugae*	Pacific Northwest	Weir 1916
Do	do	Utah	Chick 1936[3]
Do	do	Southwest	(Hawksworth)
Pinus lambertiana			
Arceuthobium "californicum"	*Dendroctonus monticolae*	California	Struble 1965 Scharpf & Hawksworth 1968
Pinus ponderosa			
Arceuthobium campylopodum	*Dendroctonus brevicomis*	Oregon	Miller & Keen 1960
Arceuthobium vaginatum subsp. *cryptopodum*	*Dendroctonus* sp.	Southwest	Korstian & Long 1922 Hawksworth 1961
Pinus edulis			
Arceuthobium divaricatum	*Ips confusus*	Arizona	(Hawksworth)

[1]Dwarf mistletoe may also affect bark beetle brood production; this is apart from predisposition. In a recent study of *Dendroctonus ponderosae*, it was found that lodgepole pines moderately to heavily infected by *Arceuthobium americanum* were less suitable as brood trees because they have thinner bark than uninfected trees (Roe and Amman 1970).

[2]References in parentheses are original; insects were identified by individual named.

[3]Unpublished National Park Service report, on file at Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

mistletoes and bark beetles more often than not occur practically in the absence of each other. An important relationship may exist, however, between Douglas-fir dwarf mistletoe, A. douglasii, and the Douglas-fir beetle, Dendroctonus pseudotsugae Hopk., in interior Douglas-fir, Pseudotsuga menziesii var. glauca (Beissn.) Franco. Beetle outbreaks have been observed to develop in mistletoe-infected stands and spread out into uninfected timber. Further work is needed to clarify this relationship.

Miller and Keen (1960) discussed dwarf mistletoe-bark beetle relationships from the standpoint of the western pine beetle, Dendroctonus brevicomis Lec., and concluded that heavily infected ponderosa pines were three to five times more susceptible to beetle attack than uninfected trees. They further pointed out, however, that the mistletoe-infected trees are probably the older and more decadent trees in a stand, a factor in old-growth ponderosa pine that often contributes to beetle attack. Korstian and Long (1922) reported that, in an area near Flagstaff, Arizona, about 69 percent of the mortality in "black jack" ponderosa pines (trees under 125 to 150 years old) was attributable to mistletoe. About half of this mortality was due directly to mistletoe and half to the parasite in association with bark beetles. Struble (1965) indicated that dwarf mistletoe is common in old-growth sugar pine, Pinus lambertiana Dougl., attacked by the mountain pine beetle, Dendroctonus ponderosae Hopkins. The association appears to be similar to that reported by Miller and Keen (1960).

Other records of dwarf mistletoe-insect relationships include (1) the tendency of twig beetles, Pityopthorus and Pityogenes, to attack dwarf mistletoe-infected ponderosa pine branches in the Southwest (Hawksworth 1961), (2) the preference of an engraver beetle, Scolytus subscaber Leconte for branches of true firs, Abies spp., infected by dwarf mistletoe (Struble 1957), and (3) the attack by wood borers in dwarf mistletoe infections on the boles of western larch, Larix occidentalis Nutt., and ponderosa pine (Weir 1916).

Edmunds and Allen (1958) found no significant difference in population density of black pine leaf scales, Nuculaspis californicus (Coleman), infesting ponderosa pines near Spokane, Washington, with and without Arceuthobium campylopodum.

Possibilities for Dwarf Mistletoe Control through Manipulation of Insect Associates

The direct dwarf mistletoe-insect relationships (pollination and predation) suggest possibilities for biological control.

Two biological approaches might be considered. The first is the standard technique of introducing or augmenting populations of phytophagous insects. The potential for this seems theoretically favorable. A second, less conventional, approach would involve limiting pollination and subsequent mistletoe reproductive capacity by controlling or repelling the pollinators. In this way, dwarf mistletoes on seed trees might be rendered harmless so the trees could be safely left to regenerate new, mistletoe-free stands.

Either of these approaches could be combined with existing silvicultural control methods or new methods yet undeveloped to provide an integrated program.

A limited amount of effort has already been put into a search for predators. During the early 1960's, C. B. Huffaker and associates at the Division of Biological Control, University of California, Albany, made preliminary studies on arthropods affecting Arceuthobium. The description of new species of mites by Kennett (1963) is a result of this activity. Hawksworth has observed arthropods on various Arceuthobium species for a number of years, with biological control in mind. The possibilities do appear intriguing, but they can be realized only if economic and other benefits justify the work necessary to develop techniques.

Field Identification of Arthropods Found on Dwarf Mistletoes

The following preliminary field key is presented to enable nonspecialists to make tentative determinations of insects and mites found in or on dwarf mistletoes. We recognize that the key is not complete and generally does not permit identification to species. We expect that a more comprehensive key can be constructed as we get more information on some of the species involved.

Field Key to Insects and Mites Known to Occur on Dwarf Mistletoes[4]

1. Mites living in or on plants	*Typhlodromus* spp.
	Brevipalpus porca
	Paraphytoptus arceuthobii
2. Adult or nymphal insects living freely in or on plants	
A. With a single pair of wings, found mostly on flowers; flies	*Bradysia* sp., and other flies
AA. With two pairs of wings or wingless--B	
B. Wings fringed, small insects generally less than 2 mm. long, mostly on flowers; thrips	*Frankliniella occidentalis*
	Frankliniella sp.
	Thrips tabaci
BB. Wings not fringed, larger insects generally between 2 and 4 mm. long; true bugs	*Neoborella tumida*
BBB. Wingless, smaller but as BB	*N. tumida* nymphs
3. Insects living within a white, frothy mass; spittlebugs	*Clastoptera obtusa*
4. Hard shelled, sessile insects; scales	
A. On *A. oxycedri*, Europe	*Chionaspis striata*
	Diaspis visci
AA. On New World species	*Niveaspis* spp.
	Hemiberlesia spp.
5. Caterpillars feeding in or on shoots; moth larvae	*Pseudoparlatoria serrulata*
A. Larvae hairy; tussock moths	*Orgyia antiqua*
AA. Larvae not hairy- - - - - - - - - -B	
B. Larvae slug-shaped, segments in folds and ridges; hairstreaks	*Mitoura spinetorum*
	M. johnsoni
BB. Larvae not slug-shaped, segments smooth	*Dasypyga atermosquamella*
	Filatima natalis
	Tortricid nr. *peronea*

[4] *If identification to species is critical, specimens should be referred to specialists. Adult forms are needed for determination of species. Unidentified grasshoppers, thrips, scales, spittlebugs, geometrid moths, weevils, and ants, not included in the key, are also reported from dwarf mistletoes (see tables on individual species).*

Conclusions

Dwarf mistletoes harbor a considerable arthropod fauna, but we know little about the details of the ecological relationships involved. Insects do play a major role in pollination, and insect feeding can severely damage dwarf mistletoe plants, at least locally. In some instances, mistletoe appears to be related to increased tree susceptibility to insects.

There are many opportunities for further study of insect-dwarf mistletoe relationships. Practical as well as scientific benefits may be obtained, since dwarf mistletoe is an economic pest, and additional control techniques are needed. Manipulation of arthropod populations would provide another approach. Utilization of phytophagous insects is an obvious possibility. Another intriguing approach, since pollination by arthropods seems to be practically obligatory, is to limit the pollinators and thus reduce reproductive capacity of dwarf mistletoe. It may also be possible to combine biological control with other control methods to provide an effective integrated control program.

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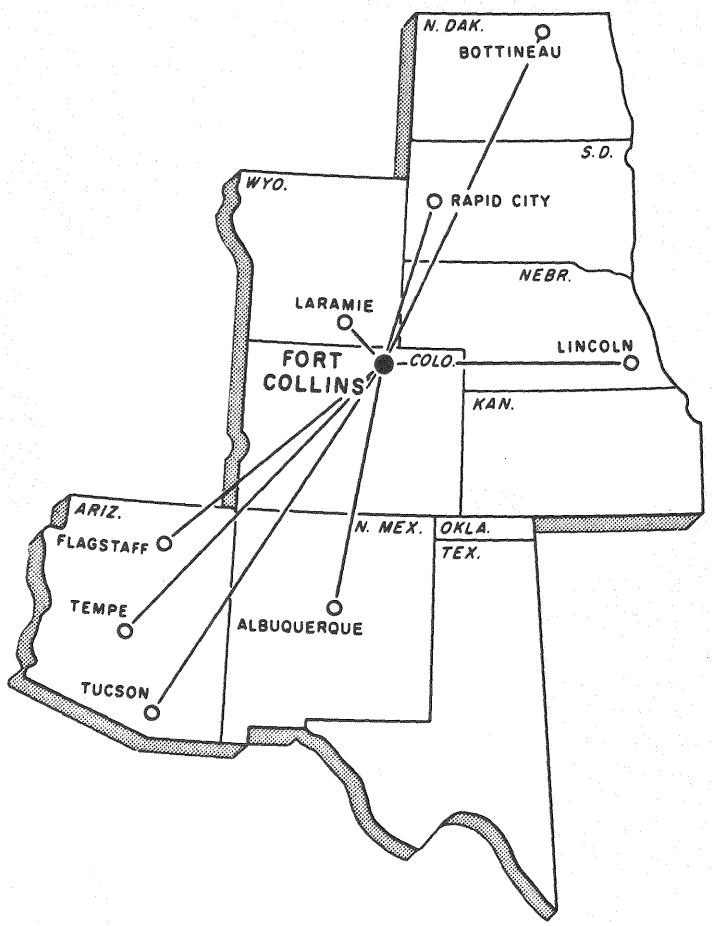
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